

# The Great Debate - Is a Formal SE Education Necessary?

*Beth Wilson (Raytheon) - [beth\\_j\\_wilson@raytheon.com](mailto:beth_j_wilson@raytheon.com)*

*Steve Henry (Northrop Grumman) - [stephen.henry@ngc.com](mailto:stephen.henry@ngc.com)*

*Garry Roedler (Lockheed Martin) - [garry.j.roedler@lmco.com](mailto:garry.j.roedler@lmco.com)*

*Shamsnaz Virani (Worcester Polytechnic Institute) - [ssv1@gv.psu.edu](mailto:ssv1@gv.psu.edu)*

*Ariela Sofer (George Mason University) - [asofer@gmu.edu](mailto:asofer@gmu.edu)*

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**Abstract.** What is the best way to become a systems engineer? Is it better to participate in a formal SE education program through a university? Is on the job training a better way to learn how to become a true SE? Panelists include university representatives who graduate systems engineers and industry representatives who employ systems engineers. PURPOSE: Learn what our experts believe is needed to build effective future SE leaders.

## Biography

**Beth Wilson** (Raytheon) - [beth\\_j\\_wilson@raytheon.com](mailto:beth_j_wilson@raytheon.com)

Dr. Beth Wilson is a Principal Engineering Fellow who earned her PhD from the University of Rhode Island. Since joining Raytheon in 1983, she has worked as a design engineer, program manager, research scientist, functional manager, and systems engineer on sonar, satellite, and radar programs. Her degrees are all in electrical engineering, yet the last 20 years of her career have been in the systems engineering organization. Her assignments have included a character-building deployment to Shemya, Alaska as a Test Director, a 2-year systems engineering effort in Virginia, and being an exchange scientist to Australia.

**Garry Roedler** (Lockheed Martin) - [garry.j.roedler@lmco.com](mailto:garry.j.roedler@lmco.com)

Garry Roedler is a Fellow and the Engineering Outreach Program Manager for Lockheed Martin. His systems engineering experience spans the full life cycle and includes technical leadership roles in both programs and systems engineering business functions. Garry holds degrees in mathematics education and mechanical engineering from Temple University and the Expert Systems Engineering Professional (ESEP) certification from INCOSE. Garry has numerous publications and presentations, and is the recipient of many awards, including the INCOSE Founders Award, Best SE Journal Article, IEEE Golden Core, Lockheed Martin Technical Leadership Award and Lockheed Martin NOVA Award. His leadership roles across many technical organizations include Chair of the INCOSE Corporate Advisory Board and editor of ISO/IEC/IEEE 15288, Systems Life Cycle Processes and several other standards.

## Position Paper

The objective in the development of Systems Engineers is to have the candidate systems engineer evolve the set of skills that allows performing the SE activities with competence and proficiency. The development of any skill requires a combination of knowledge (gained from education or training) and experiences (gained from performing the activities in actual situations). So neither the formal education, nor the on-the-job training by themselves is the best path for developing systems engineers. The knowledge component can take several forms, one of which may be a formal SE program in a university. Although the formal SE program is likely to provide the best and most focused set of knowledge for the developing systems engineer, especially if the program conforms to the Graduate Reference Curriculum for SE (GRCSE), it is not the only learning path. [At the end of 2012, the BKCASE project published GRCSE. It was developed by an international body of subject matter experts and it is aligned with the SE Body of Knowledge (SEBoK) and key SE standards and references.] The key in the knowledge component is to ensure that the candidate obtains the appropriate set of knowledge that will provide a solid foundation to draw from. So, the formal SE program will ensure the foundation knowledge is obtained. However, other paths to obtain the knowledge can include 1) other engineering graduate degrees that have a number of related courses (although it may require some supplemental information), and 2) a curriculum of training and education developed by an enterprise to

address the foundation knowledge in a manner that is tailored to their domain. But it is not likely that the developing systems engineer will gain enough of the foundational knowledge just through on-the-job learning without some level of structured curriculum of educational and/or training courses. The experiences component cannot be easily be replaced by academic exercises, simulations, or other activities that are not actual application of SE in the project environment. That means the experiences component needs to primarily consist of on-the-job opportunities to apply the foundational knowledge. That is not to say that the supplemental activities, such as academic capstone projects, experience accelerator (as from the SE Research Center), and situational simulators are not helpful – they are. But they do not replace the long-term experience gained from working day-to-day on challenging projects applying the SE knowledge. It is the continuous practice in the actual situational environment, applying the knowledge, performing the analysis and making recommendations/decisions that then turns the knowledge into skills.

**Shamsnaz Virani** (Worcester Polytechnic Institute ) - [ssv1@gv.psu.edu](mailto:ssv1@gv.psu.edu)

Shamsnaz Virani is the Senior Lecturer for Systems Engineering at Worcester Polytechnic Institute. She was previously Assistant Professor at Penn State Great Valley campus. Before coming to Penn State, she was a Research Assistant Professor at Research Institute of Manufacturing Engineering Systems (RIMES) at The University of Texas at El Paso (UTEP). She has a BS in Electrical Engineering from University of Pune, India, a Masters in Human Factors Engineering from Wright State University, Dayton, OH and a Ph.D. in Industrial and Systems Engineering from The University of Alabama at Huntsville. She has a Six-Sigma Green belt and is a Lean Certified Professional. Her research areas include software systems engineering, engineering education and mental models. At RIMES, she collaborated with computer science department in developing a National Science Foundation (NSF) funded software engineering track enhancing the Masters of Science in Systems Engineering (MSSE) program. She has also designed and developed three graduate systems engineering courses (Systems Engineering Fundamentals, Integration Verification Validation and Systems Modeling) and a systems engineering module for high school. She in collaboration with a local the high school and educators developed a four year engineering curriculum to teach engineering in high school. She also works with a multidisciplinary research group that uses an artificial intelligence (AI) based technique to develop shared team mental models to better understand team mental model convergence. She has published in several peer-reviewed journals and conferences in Software Engineering, Engineering Education and Engineering Management. She routinely reviews journal and conference papers, and NSF proposals.

#### **Position Paper**

Pro Formal SE education at Graduate Level CNN Money ranked Systems Engineer as number one in their 2009 best jobs in America category. In that article they clarify that systems engineer is no longer 'a niche job in the aerospace and defense industry' but find 'diverse employers from medical device makers to corporations like Xerox and BMW' The best way to prepare a systems engineer for a diverse workplace would require a balance of formal university education and on job training. I think it's important that every systems engineer be an engineer first, so have bachelors in engineering that establishes the depth of knowledge in an engineering discipline and then develop a broader understanding of systems through a formal graduate degree in systems engineering program. The graduate systems engineer programs include project based learning pedagogy that helps the students with experiential learning opportunity simulating on job training. While there is no replacement for on job training when you are employed as a systems engineer, it takes atleast a couple of decades accumulating that experience that can sometimes be very domain specific. A formal university education for the most part remains domain independent developing the systems engineer for today's diverse workplace. Another advantage of formal systems engineering is the introduction to different aspects of system engineering profession such as requirements analysis, verification and validation, and systems management. Most formal university systems engineering programs inculcate appreciation of different aspects and develop mastery in their application to systems engineering projects.

**Ariela Sofer** (George Mason University) - [asofer@gmu.edu](mailto:asofer@gmu.edu)

Ariela Sofer is a Professor in the Systems Engineering and Operations Research (SEOR) Department at George Mason University, and (since 2002) Chair of the Department.. Dr. Sofer has served as Vice President for Sections and Societies of The Institute for Operations Research and Management Science (INFORMS), and President of the Association of Chairs of Operations Research Departments. She was co-chair of the

SIAM Conference on Optimization held in 2002 in Toronto Canada, and co-chair of the 3rd International Conference on Model-Based Systems Engineering held in Fairfax, Virginia, 2010. She is coauthor (S.G. Nash) on the book 'Linear and Nonlinear Programming,' McGraw-Hill 1996, and its second edition 'Linear and Nonlinear Optimization,' SIAM 2009. She has held a number of editorial positions and is currently a member of the SEBoK Editorial Board and the MOS-SIAM Book series on Optimization.

### **Position Paper**

There is no single best way to become a systems engineer. Clearly there are amongst us many senior systems engineers who have learned the profession through years of practice and through involvement with projects of scope and complexity that could not possibly be experienced within a formal educational program. At the same time one can always benefit from a formal education. For the seasoned systems engineers a formal program helps rationalize their catch-as-catch-can training, provide a logical framework for their knowledge and fill in inevitable gaps. For the novice engineer a graduate systems engineering program vastly accelerates the preparation necessary for a career in systems engineering, by providing necessary knowledge of the systems engineering methodology as well as a systems engineering perspective. And an undergraduate systems engineering degree produces engineers who are trained to think holistically, who have an understanding of systems processes and methods, and have strong analytical skills to support decision making in engineering design. These capabilities are not provided by any other engineering degree, and prepare graduates to start work immediately as junior engineers in the support of the design and development of complex systems.